

WHAT IS CLAIMED IS:

1           1.     A cleaning solution capable of selectively removing a damaged portion of  
2 a ferroelectric layer, the cleaning solution comprising:  
3           a fluoride;  
4           an organic acid with carboxyl group;  
5           an alkaline pH adjusting agent; and  
6           water.

1           2.     The cleaning solution of claim 1, wherein the pH of the cleaning solution is  
2 about 4.5 to about 6.0.

1           3.     The cleaning solution of claim 1, wherein the fluoride is hydrogen fluoride,  
2 hydroboron tetrafluoride or ammonium fluoride.

1           4.     The cleaning solution of claim 1, wherein the organic acid is formic acid,  
2 acetic acid or citric acid.

1           5.     The cleaning solution of claim 1, wherein the alkaline pH adjusting agent is  
2 ammonium hydroxide, potassium hydroxide, tetramethylammonium hydroxide or  
3 tetraethylammonium hydroxide.

1           6.     The cleaning solution of claim 1, wherein the content of the fluoride is  
2 about 0.01% to about 1% by weight based on the total weight of the cleaning solution.

1           7.     The cleaning solution of claim 1, wherein the content of the organic acid  
2 with carboxyl group is about 1% to about 50% by weight based on the total weight of  
3 the cleaning solution.

1           8.     The cleaning solution of claim 1, wherein the content of the alkali pH  
2     adjusting agent is about 0.25% to about 15% by weight based on the total weight of the  
3     cleaning solution.

1           9.     The cleaning solution of claim 1, wherein the damaged portion of the  
2     ferroelectric layer to be removed with the cleaning solution includes the surface of the  
3     ferroelectric layer passed through annealing after deposition, or the surface of the  
4     ferroelectric layer passed through an etching process.

1           10.    A method of selectively removing a damaged portion of a ferroelectric  
2     layer with a cleaning solution, the method comprising:  
3         providing an integrated circuit substrate having an exposed ferroelectric layer  
4         with the damaged portion; and  
5         contacting the exposed ferroelectric layer with the cleaning solution, said  
6     cleaning solution including a fluoride, an organic acid with carboxyl group, an alkaline  
7     pH adjusting agent, and water.

1           11.    The method of claim 10, wherein the exposed ferroelectric layer includes  
2     the surface of the ferroelectric layer passed through annealing after deposition on the  
3     integrated circuit substrate, and the step of making the exposed ferroelectric layer  
4     contact the cleaning solution includes etching back the ferroelectric layer by about 100  
5     Å to about 500 Å from the top of the ferroelectric layer.

1           12.    The method of claim 10, wherein the exposed ferroelectric layer is  
2     interposed between upper and lower electrode layers, and the method further  
3     comprises forming a capacitor by patterning the upper electrode layer, the ferroelectric  
4     layer and the lower electrode layer, before contacting the exposed ferroelectric layer  
5     with the cleaning solution.

1           13.    The method of claim 10, wherein the pH of the cleaning solution is about  
2   4.5 to about 6.0.

1           14.    The method of claim 10, wherein the fluoride is hydrogen fluoride,  
2   hydroboron tetrafluoride or ammonium fluoride.

1           15.    The method of claim 10, wherein the organic acid is formic acid, acetic  
2   acid or citric acid.

1           16.    The method of claim 10, wherein the alkaline pH adjusting agent is  
2   ammonium hydroxide, potassium hydroxide, tetramethylammonium hydroxide or  
3   tetraethylammonium hydroxide.

1           17.    The method of claim 10, wherein the content of the fluoride is about 0.01%  
2   to about 1% by weight based on the total weight of the cleaning solution.

1           18.    The method of claim 10, wherein the content of the organic acid with  
2   carboxyl group is about 1% to about 50% by weight based on the total weight of the  
3   cleaning solution.

1           19.    The method of claim 10, wherein the content of the alkali pH adjusting  
2   agent is about 0.25 % to about 15% by weight based on the total weight of the cleaning  
3   solution.